Female: So just for the record can you state your name and your position?

CM: I'm Clive Marsh and I'm Chief Scientist for AWE at the moment.

Female: And I guess we'll start with the earlier days, I guess you came to AWE in 1968. Can you talk a little bit about the early years and what you did at AWE in the beginning?

CM: Yes, I joined AWE actually not straight from university as a graduate but from NASA where I had been working on some of the space work and joined in 1968 as a mathematician into the Theoretical Design area. We at that time had our Polaris system and our WE177 so we had our deterrent and we'd actually already embarked on a self imposed nuclear test moratorium so we weren't actually doing very much warhead design at all. My interest then, in those early days were on fundamentals of thermonuclear burn and I actually got interested in ICF using lasers to stimulate the thermonuclear activity. That was in 1969 and some of my early interactions with the United States came a few years along on that path interestingly at that stage neither of us shared that interest but it became possible within a couple of years.

Female: Ok, so the MDA was already signed by that time but there were limitations on being able to talk about the…

CM: Yes, I think that's fair to say, that we in AWE at the time perhaps didn't have the confidence at the time to approach these things with the United States. We were novices in the area, exploring it very much in the conceptual sense so perhaps that lack of confidence existed. I think it's also fair to say that the interactions between us reflected the lack of warhead design activity. I've subsequently used the exchange, the depth of exchange between us as Litmus paper as a monitor as a barometer if you like of the strength of our capabilities. My feeling in 1968 and the early years was that (?) exchanges were good they weren't as vibrant as perhaps they might have been and they're certainly no where near as vibrant as they are now. I think that matched with the fact that the AWE technical capability was perhaps a little bit on the decline at the time and polite though the United States were, we could detect it in the level of that exchange, so a bit of a lack of confidence I think. Which we really didn't recover until we got back into the Shevlin(?) program, back into design and back into nuclear testing.

Female: And the mechanism for exchanges with the United States has always been these Joint Working Groups or JOWOGs. Can you talk a little bit about the way a JOWOG works, how it's structured, the formality or lack thereof, of a JOWOG?

CM: I think I'd describe a JOWOG almost in general as a conference, conference mode activities working together towards common objectives, but not

necessarily working strongly hand-in-hand doing work with one another. More an issue of sharing the work that we're doing in a common direction and then if you like, share it, separate go away, do your own thing, come back, conference mode and do that again. That was the entire way of JOWOGS but it's the principle way that they've gone through hugely valuable, generic science, not necessarily targeted at a particular project there's project activities when we really did have a close interaction with specific imperatives to be resolved we're often stimulated really and lead by the test program and in particular the United Kingdom's nuclear test objectives.

Female: Ok, and that's a good segway into our underground testing coordinated efforts, we, you did several tests at NTS and I haven't talked with you enough to know, what specific test program to ask about but can you talk a little bit about your experiences with underground testing?

CM: Yeah, as I say we return to nuclear testing in 1974 and I at the time didn't have an awful lot of involvement, my engagement began actually in 1978 with the United Kingdom test called Finholm(sp?) and even there I wasn't involved in the actual design of the device itself, but the philosophy that the United Kingdom took that AWE took when we went back to testing was really to get as much out of the rather few tests that we did get as much physics understanding as we could with comprehensive diagnostics suites. We actually fielded diagnostics which at the time we couldn't compute but we gathered the data which turned out to be actually key data, we tend to call it the crown jewels now, of the way warheads operated but I wasn't involved in either of those things, the design of the main device nor of the diagnostics but actually we used to field additional experiments underground that were if you like driven by the energy of the main device and which enabled us to identify and study particular design physics issues on a very small scale that's where I started my engagement with it in 1978 but I moved on to the design of real devices and in particular to the Trident warhead system.

Female: Ok great, that's good opening the part about the side cars…

CM: Yeah, yeah tack-ons we call them…

Female: So the trident warheads, so when you started getting involved with the actual design of the Trident warhead, was the emphasis again on more underground tests, your emphasis is that where we should go from here?

CM: Yes, we can go that way; let's continue down that track, at some stage we need to bring in the laser…

Female: Ok

CM: And the Hydrodynamic Facilities but let's track along as we go and see what happens.

Female: Alright so we're up to 1978 I picked up…

CM: That's correct.

Female: Ok, ok tell us a little bit about the, your efforts in underground testing of the Trident warhead.

CM: Well as I say in 1978 I tested some small, what we call tack-on experiments they had a particular reason; their aim was to understand some of the physics associated with design principles which could actually miniaturize warheads. The trident system is particularly small and light, needs to be highly refined and needed that kind of information to enable us to take the understanding that we got from previous systems, rather larger systems like shevlin(?) and actually make it smaller, make it lighter, make it work if you like in a system which was small and defined, the Mark IV reentry system of Trident as provided by the United States. So I carried that through and began to work more myself on the design of those devices, actually rather more leading the design, I was by then superintendent of the physics design and I had experts in primary design and secondary design who actually did the reality but I helped to draw it all together the theoretical side, the hydrodynamic side and of course of the radiation transport side. As part of that activity as we prepared to go to our first test of our Trident warhead conducted in 1984 actually. We were using the sort of facilities that now are appropriate as we look into the comprehensive testament treaty era and no testing so we put an awful lot of effort into hydrodynamic simulations, contained firings, simulated everything about the primary design except of course there was no (?) material in there and in addition we had introduced by then a high power laser, we call it the Helen laser, short pulse, very high power which we conceived of in 1975 built with the help of sheva(?) parts in fact from Livermore and her majesty the queen opened that facility, the Helen Facility in 1979, but that enabled us to study some of the physics of high temperature plasma, the sort of conditions that you, that occur in a nuclear weapon. Those two aspects combined with supercomputing, hydronamics, the laser, supercomputing our design experience of what we carried forward and enabled us with collaboration with the United States, a lot of collaboration with the United States to actually target those first trials of our Trident warhead; the first two were conducted in 1984. I wasn't directly involved in the pulse power capabilities themselves although I knew Charlie Martin and his team, they were leading people, they created what we call our Mogul machines now which are very high power pulsed radiographic machines which are part of that capability for understanding and looking at warheads, the performance of warheads as simulants with no plutonium obviously. So I wasn't involved directly myself in the technology, but I was involved in using the technology. In Nevada, the

way it panned out we interacted separately with Livermore and Los Alamos and alternately in fact so one test would be done by Livermore and we'd work with them with their methods the next time we would be with Los Alamos this was actually quite advantageous to the United Kingdom because we were getting a spread of the total capabilities. The way in which we designed the tests though was through our own efforts if you like, we designed the device, we designed the diagnostics that we needed but we drew on diagnostics from the United States and we drew on the advice, obviously of the experts in the United States to tell us what developments might be brought to bear we shared with them all of the design of the device that we were studying, we shared with them the issues we really wanted to resolve and between us, we constructed a suite of diagnostics, a comprehensive suite of diagnostics to get the maximum out of that trial. Of course we shared all of the information with the United States we did common calculations, well calculations using our own methods to predict what would happen we had to do that for safety anyway but we did it before the tests, we did it after the test we shared all of that and in that manner helped mutually to build our capabilities. The United States also shared with us a number of underground tests which they saw to be relevant to our design objectives so in that manner we were able to gain that benefit before we actually did the nuclear test and helped us to ensure success.

Female: Ok good. Alright we don't even have to talk about Ice Cap (laughing)…

CM: Don't talk about Ice Cap (laughing)…or all the other ones under the hat field; we had some fun actually on that.

Female: Well actually I was joking, is there anything from that era, the end of, just before the closure of NTS that might be relevant.

CM: Well yes, I think so we've talked about Trident in 1986 but even as we were working on that replacement of the submarine launch system, the replacement of Shevlin(sp?) we were also thinking of replacing our WE177 air delivered system, so we were moving to that class of device a different class of device enhancing safety using space to enhance their safety with different materials, different explosives and so on. So as we went through the late 80's and moving into the 90's we'd set out an approach to develop those methods and actually to look at some research approaches as well which we thought in the long-term would enhance robustness, take us into our advanced safety principles and things of that nature. We tested the first two of those really in 1990 and 1991 and we had a whole series of them lined up to take us forward through the 1990's, but yes we were interrupted, Ice Cap was out there almost ready to go as the first of that follow-on series when the agreement to discontinue nuclear testing was upon us. Ice Cap is still out there in Nevada without the nuclear device of course, but that's the last of them from the United Kingdom's point of view, our last test was 1991.

Female: Ok, WE177 that was not pursued was it?

CM: No, no that's correct.

Female: And that's why, because of a lack of ability to test?

CM: Not necessarily so, I think this is one where you need to talk to the policy people, but no I think as we went through into the 1990's a number of things emerged for the United Kingdom. The first was we stopped nuclear testing, we ratified the CTBT later in the 1990's so that's the end of testing for us but the other thing was the government did decide not to replace the air delivered system and to rely on the single Trident system for our deterrent, that decision of course, well the two issues brought the challenges for us to sustain deterrents into the future and that's really what we've been focusing on with the United States ever since, since '93, '95 that sort of time frame.

Female: So this is a question that you've probably been asked a hundred times but its one that just persists so, in the absence of underground testing how confident do you feel in being able to maintain our warheads or design?

CM: I think it's a very good question this issue of confidence, we were concerned in the 1990's that actually confidence would grow as experience declined, it sounds a little bit counterintuitive but in fact that was one of the issues and we are losing the experience of testing now so the people that actually were there experience difficulties, surprises that came out of the blue, those experiences are beginning to drift out of the consciousness, meanwhile people are inclined to be using more computer aided processes they're very impressive I asked to look at 2 and 3D simulations to see how convincing they are but the key for us and the United States we recognize it all along is to make sure that we validate the confidence so how confidant are we at the moment? I think we're growing in confidence and I think we are validating that confidence but we're not there yet, the tools that we need to be able to assure that first of all in aging warhead is still acceptable if the ages have not taken performance or safety, perhaps more importantly safety out of the bounds of acceptability satisfactory so far because the ages of system are not too long, about 10 years, but we need to look at those hard and we are doing, when it comes to a new device, again we're developing techniques to help us to use the existing nuclear test experience but see how far we can move away from that necessarily you have to move away materials are changed, processes have changed and you have to achieve that confidence, we have to achieve validated confidence. One of the principle ways we will do that is through peer review having independent methods of actually assessing and certifying our warheads, assessing the aging effects, assessing the affects of new materials and so on we're developing different ways of doing it based on our experience ours was an experience with relatively few underground tests but a lot of diagnostics, the United States had a much richer nuclear test database by

working those things together we can share and benefit from data but our methods remain independent and I think it's those differences, actually it's the differences almost rather more than the commonalities that are the strength and what bind us together in this relationship, peer review is crucial for that validation.

Female: That's a taker.(laughs) So let's see, you know I think that we've covered the weapon development through probably as far as we need to. Is there anything else in this scene 5 which is other activities that support the programs? You've talked a little bit about lasers and I'll leave it up to you, is there anything we left out?

CM: I think those are the main ones actually I think its fine.

Female: Ok, well it's to the end then…

CM: Yeah

Female: Because the last bit we wanted to get to was the meaning of the US-UK relationship and where this 58 agreement will take us from here, what you see as the future of the value in our collaboration as time moves forward.

CM: Yeah. As I say I think the maintenance of independence in certain core areas, that is validation of our confidence in the design processes and certification, I think that will remain right at the heart of this relationship between us but there are many things that we can do together and I believe we will be doing together. As in the past the shape of the interaction was very much as I said earlier governed by the underground test activities now their governed rather more by this development of stop past(?) stewardship methods but also by the fact that our facilities are aging many of those at AWE are 50 years old or so. I know that United States have similar problems so there are certainly things we can do working together with commonality now because independence doesn't matter where we can take advantage of understanding what one another's ideas are, design ideas for facilities different techniques for manufacture and so on, I think we can work those things. So the way that we're trying to shape the exchange now there will still be the JOWOGs, there will still be the generic exchanges which are hugely important but what we've tried to do is to pick out some enhanced collaborations and to do that we've taken a look at and shared our strategies, our technical strategies for the long-term, possibly looking forward 20-25 years at the kinds of things, the challenges that lie ahead what we'll need to be able to do with one another. As you draw back from those objectives which can be as long as 20-25 years away you can see that decisions need to be made in the next few years that will actually take you to those objectives and that's what I think the focus is now we're sharing our strategies, long-term strategies best as we can, nothing's absolutely fixed is it, but you know often your framework is quite

good. We're focusing on the key decisions where together we can make the right decision for economy, saving money, doing things the best possible way and we're shaping some new enhanced collaborations which have imperative to them, imperative in an early objective to make a decision, imperative of time so we make it at the right time so then we can achieve the long-term aims again working together long-term. I say again preserving that independence when it comes to the critical core independent issue of design and assessment.

Female: Ok, excellent. Any final thoughts, you know, looking back you've been involved a long time in the US and UK interactions, any finals thoughts on what you think maybe were the most valuable benefits of the collaboration, you've talked about purity so I don't want to make you say something again…

CM: No

Female: …maybe just a different way of looking at it, to sum up the value of the collaboration over your career.

CM: Well I think the biggest thing and we've not mentioned it yet but it is probably the biggest so the relationships between people, none of these things work if you don't actually find the people that you synergize with, that think similarly that are prepared to move forward with commitment to achieve. I've been, I won't say I've been fortunate because I think many people have been in the same position as myself is finding people on the United States side who do think differently, have different background experiences but yet share this common desire, this common aim of making our deterrent last, making it effective and the relationships that we've built up over many years often have been the key to the success so far. I'm now approaching my retirement but I'm delighted to look at the way things are working now, the JOWOGs are working well, there are good relationships between the leaders we can see that, the enhanced collaborations is a real excitement to take those things forward, we've identified the leaders on either side, they're gelling together superbly well so I'm fully expecting all this to succeed and to succeed because of people.

Female: Thank you very much

CM: Thank you